PECULIAR HABITAT OF A PYCNOGONID (ENDEIS SPINOSUS) NEW TO NORTH AMERICA, WITH OBSERVATIONS ON THE HEART AND CIRCULATION.[1]

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During the summers of 1904, 1905 and 1906, sargasso, or gulf-weed, at various times drifted into Vineyard Sound in considerable abundance. This is the case some years, while others it may seldom be seen or may be wholly absent during the entire season. Gulf-weed is borne northward each season in large quantities by the Gulf Stream, which here lies nearly a hundred miles off the coast, and its appearance in these in-shore waters would seem to depend in large part upon the occurrence and prevalence of southerly and easterly winds, which divert a certain amount of it shoreward from its course further out. In 1904, and presumably also in the two succeeding seasons, although my records do not state specifically as to this, the weed was covered with a delicate but very abundant growth of the hydroid *Obelia dichotoma* (Linn.).[2] Living among the colonies of this hydroid, and clinging tenaciously to its stems and branches, occurred a slender pycnogonid, a species of *Endeis*, both adult males (many of them carrying eggs) and adult females, as well as young in various stages of growth, being found in great numbers.

The largest of these pycnogonids were of a considerable size, being approximately 15 mm. across from tip to tip of the extended legs; but all were nearly white, or of a light straw color, in general appearance, which rendered them far from conspicuous among the similarly colored hydroid stems. Examined individually, with more care, it was found that the intestine and its diverticula in the legs usually appeared greenish, probably due to its contents, while there was a pinkish tinge at each of the articulations of the different joints (articles) of the legs. When

[1] The observations reported in this paper were made in the laboratory of the United States Bureau of Fisheries at Woods Hole, Mass.

[2] The identification of this species was kindly confirmed for me by Professor C. W. Hargitt.

the intestine was empty, the legs often appeared white at the joints (articulations) and transparent between. The distal half of the proboscis is usually the most conspicuous part of the animal, being a tinge or shade of yellow, in some cases so dark as to be almost buff. Eyes dark reddish brown.

While this pycnogonid was found plainly to belong to the genus *Endeis* (*Phoxichilus*[1] of authors), its peculiar occurrence among the gulf-weed, and the fact that the genus had never been reported from American waters, led to the suspicion that it would prove to be specifically distinct from any described form. Comparison, however, with descriptions of *Endeis spinosus* (Montagu) of the European coast showed so little discrepancy that I have delayed coming to a definite conclusion until I should be able to compare it directly with specimens from that locality. This I have now been enabled to do through the kindness of Prof. G. O. Sars, of Christiania, Norway, and Mr. T. V. Hodgson, of Plymouth, England, who have generously supplied me with

[1] The name for this genus has been commonly known and accepted as *Phoxichilus* since 1837 at least. It now appears that the first form described as a *Phoxichilus* in reality belongs to Wilson's genus *Pseudopallene*. According to the iron-clad "law of priority" therefore, the name *Phoxichilus* must now be used in place of *Pseudopallene* for that genus, and hereafter all but specialists on Pycnogonida will find what is to them an almost hopeless confusion of names if they ever have occasion to look up the literature on such a subject, say, as the circulation of the blood in this group, mentioned later in this paper. Stebbing (1902, p. 187) proposed the name *Chilophoxus* to take the place of *Phoxichilus* for those animals which have been universally known by the latter name. But the evil ball once started rolling could not be stopped here, for Norman (1908, p. 231) has pointed out that undoubtedly the first species described by Philippi (1843) under his genus *Endeis* "is congeneric at least, if not identical, with *P[halangium] spinosum* Montagu," which has so long been known as *Phoxichilus spinosus*, and is the subject of the present note. This being the case (and there would appear to be no doubt of the facts) *Endeis* of course takes precedence over *Phoxichilus*, and the name must therefore stand as *Endeis spinosus* (Montagu).

When I began systematic work on the Pycnogonida, more than ten years ago, I believed implicitly in the advantages to be gained by following strictly the law of priority; after considerable experience in observing its effects, I am inclined to agree with Thompson (1909, p. 537, footnote) when he remarks with regard to the instance just discussed: "In my opinion this is a case where strict adherence to priority would serve no good end, but would only lead to great and lasting confusion." However, after much mental contention, I have decided for the present to be law-abiding, and to live in the hope that before long an agreement may be reached among zoölogists permitting the use of common sense in place of forcing blind adherence to a law which, however good its intention, has seemed only to increase the instability and confusion in zoölogical nomenclature.

specimens of undoubted *Endeis spinosus* from the Norwegian coast and from Plymouth, respectively. Furthermore, I have had one specimen, labelled "*Phoxichilus vulgaris*," which I feel confident came from Naples, although no locality was given on the label. My reasons for believing that this specimen came from there are twofold: First, because it was with other Mediterranean pycnogonids, and second, because the name *vulgaris*, which European writers unanimously consider as a synonym of *spinosus*, has been used for this species only in that locality. Finally, in addition to those from Vineyard Sound I have from the American side of the Atlantic a number of specimens of *Endeis* from the Tortugas, Florida. One of these I collected myself; the others were kindly sent to me by Dr. A. G. Mayer, director of the Marine Laboratory of the Carnegie Institution.

After having compared carefully the specimens from these five widely separated localities, viz., Naples, Plymouth, Norway, Vineyard Sound and the Tortugas, I am forced to the conclusion that in spite of their range and their difference in habitat, they in reality must all be considered as belonging to a single species, *Endeis spinosus* (Montagu). The Vineyard Sound specimens, it is true, appear in general a little stouter than those from Norway, due to the legs being proportionately a trifle shorter; this difference, however, is not great and is inconstant. The following table presents a number of proportions, based usually on the average of measurements of all the legs of from one to three or four specimens from each locality. The numbers of specimens measured were so small and the results are in general so irregular that not much importance can be attached to them. It will be noticed that in the proportion of the length of the femur to that of the coxal region, there is a gradual relative shortening of the femur as one goes from Naples up the European coast and down the American side to the Tortugas; the same is true in a general way for the relation of the trunk to the proboscis; while the relation of the trunk to total leg length is more irregular. This gradation in two of the cases may or may not have any real significance.[1]

[1] Owing to the comparatively small amount of differentiation in the four pairs of walking legs of the pycnogonids and to the fact that they present characters

Proportionate Measurements of Endeis spinosus from Different Localities.

Localities.	Ratios.		
	Coxa to Femur.	Leg to Trunk.	Proboscis to Trunk.
Naples	1 : 1.80	1 : 3.55	1 : 2.35
England	1 : 1.70	1 : 4.14	1 : 2.01
Norway	1 : 1.68	1 : 3.85	1 : 2.14
Vineyard Sound, ad.	1 : 1.66	1 : 4.15	1 : 1.83
" " juv.	*1 : 1.32*	*1 : 3.26*	*1 : 2.03*
Tortugas, ad.	1 : 1.43	1 : 3.74	1 : 1.92
" juv.	*1 : 1.29*	*1 : 3.53*	*1 : 1.89*

Of even more interest than the mere fact of the occurrence of *Endeis spinosus* on the American coast is its peculiar pelagic habitat on this side of the Atlantic. So far as I am aware, a pelagic habit among the Pycnogonida has not heretofore been reported, either for this species, which in Europe has been recorded as dredged from shallow depths, or any other. In a previous paper (Cole, 1901, p. 197) I have called attention to the fact that *Pallene brevirostris*, a very slender pycnogonid which occurs at Woods Hole, swims actively if by chance it becomes free in the water; but ordinarily it lives among the hydroids and algæ growing attached in shallow water. Curiously enough the specimens of *Endeis* from the Tortugas sent me by Dr. Mayer are all recorded as having been obtained from the "surface" or in the "tow." And in addition to these he has also sent me several specimens of *Pallene* and *Nymphon* (species as yet undetermined) which were obtained in the same manner. While enjoying the privileges of the Carnegie Laboratory at

(linear dimensions) which can be measured with ease and accuracy, it would seem that these animals present exceptionally favorable material for a statistical study of differentiation and correlation of these appendages. What observations and measurements I have made would seem to indicate, for example, that the ratio of the length of the legs to the body, and the correlation between the legs themselves, varies with the age of the animal, and that there is a positive correlation between the age of the individual and the position of the legs from behind forward. In other words, the posterior pairs of legs present more juvenile characters than the anterior ones. Such a study could be made profitably only on a species which could be obtained in abundance at all stages of growth. The species under consideration would be excellent for such a study, and *Anoplodactylus lentus* is another that may be obtained abundantly at Woods Hole. Whatever else of general interest might be learned, the results would be of the greatest value to the systematist in this group, who has usually to deal with a small number of specimens taken at scattered localities.

the Tortugas in 1906, I myself obtained a live specimen of *Endeis spinosus*, the animal appearing in a finger bowl which I had just filled with sea water by means of a hand pump used for that purpose, thus showing that the pycnogonid must have been swimming freely in the water when it was sucked in by the pump. Whether these pycnogonids which were taken at the surface had merely become accidentally detached from their regular abodes, or whether certain species naturally swim freely in the water at certain times, I am not prepared to say.

In the present connection the reaction of certain pycnogonids to light is of considerable interest. I have shown (Cole, 1901) that *Anoplodactylus lentus* and *Pallene brevirostris*, both of which can sustain themselves in the water by swimming,[1] move uniformly toward a source of light of moderate intensity (diffuse daylight). I was, furthermore, able to prove the same thing for *Endeis*, at least for the one specimen mentioned above as secured by myself at the Tortugas, the reaction being in all respects similar to that previously described for the other genera. The biological significance of this reaction in the case of *Endeis*, living among the hydroids on the gulf-weed, is at once apparent, for any individual which by chance became detached from the hydroid would, in response to the light coming from above, swim upward instead of going down into the deeper water, and would in this way stand a much better chance of again finding suitable attachment. From the fact that the young of all stages appeared to be clinging as tenaciously to the hydroids as the adults, I am inclined to believe that they probably do not have a definite free swimming stage, but swim only when circumstances make it necessary.

The newly hatched larvæ possess strongly developed chelifores and stout chelæ by which they attach themselves to any available object. Normally they remain clinging to the egg cluster on the legs of the male for some time after hatching. The usefulness of these effective grasping organs is readily apparent, since without them the larvæ would almost inevitably become detached and lost from their floating abode. I have elsewhere (Cole, 1904, p. 316) pointed out the usefulness of the chelifores

[1] The "swimming" consists simply of a vigorous *kicking*.

in preventing pycnogonid larvæ from being swept off the hydroids by a swift tide. After metamorphosis the claws of the walking legs are used for attachment, while the chelifores then probably serve as feeding organs, as has been observed to be the case in *Anoplodactylus* (Cole, 1906) and *Phoxichilidium* (Loman, 1907).

It seems worth while to call the attention of any who might care to investigate the embryology or anatomy of this group to the advantages of this species should it continue to appear in Vineyard Sound, where it is so readily accessible to the marine laboratories at Woods Hole. During the seasons it was observed all stages for a study of the embryology and later development were present in great abundance, while owing to its transparency, it is very favorable for observing the internal anatomy, as well as some of the physiological functions of the living animal. The peristaltic movements of the intestinal ceca in the legs are easily discernible, and our knowledge of the circulation of the blood in the pycnogonids has been derived largely from this species. The passage of food through the intestine and the extrusion of feces has been well described by Loman (1907) in the case of *Phoxichilidium femoratum*.[1] The question of the circulation has been touched upon by a number of observers, being most thoroughly considered by Dohrn (1881), but as this author makes no mention of earlier writers, it may be well to give here a brief résumé of the literature on the subject, together with a few additional observations.

Johnston (1837, pp. 374 and 379) appears to have been the first to mention a circulation of the fluids in the pycnogonid, his observations being made on the living "*Orithyia coccinea*" (= *Phoxichilidium femoratum*). Johnston, however, apparently mistook the branching intestine for blood vessels, for he says (p. 374): "The circulating system is probably reduced to a single vessel which occupies the centre of the thoracic segments, and sends a branch to each member or limb, in which the blood has an irregular movement, but cannot be said properly to circulate." On p. 379 he adds that "there is no heart." Milne-Edwards, in his "Histoire naturelle des Crustacés" (1840, p. 531), dismisses

[1] *Phoxichilidium femoratum* is well known on our coast to the northward of Cape Cod.

the matter with the statement that there exists "une circulation vague." According to de Quatrefages (1845, pp. 75, 76) no heart or vascular system exists, but the blood is agitated back and forth in part by the movements of the legs and also by the muscular movements of the intestine, which he believed to lie freely in the internal space of the legs. Van Beneden (1846, pp. 72, 73), observing a living *Nymphon*, was the first to make out a regular circulation. He states that the blood may be seen to flow down one side of a leg and back the other, then into the next following leg, and so on to the last pair, after which he could not tell what course it takes. On account of the opacity of the intestine he could not determine whether there was a heart or dorsal vessel present, but he observed a contractile membrane at the bases of the legs. (It is probable that what he saw were the valves of the heart where that organ extended beyond the outline of the intestine.)

Zenker (1852, pp. 382, 383), also studying *Nymphon*, was apparently the first really to see the heart. He describes it as a thin-walled sac with ramifying muscle fibers, the contour being most clearly discernible in the region of the last pair of legs. Three years later Krohn (1855) published a much fuller description of the circulation, together with a figure of the heart of *Endeis spinosus*. Hoek (1881*a*, 1881*b*) described the structure of the heart in *Colossendeis* and certain other forms. According to him there are ordinarily three pairs of lateral ostia (the posterior pair being very close together) except in *Pallene brevirostris*, which has but two pairs. In the same year Dohrn (1881) published the best description of the structure of the heart and of the circulation that has yet been given, his description being based principally again on *Endeis*. He found here two pairs of lateral ostia, with commonly, but not always, an unpaired aperture at the posterior end. There are no blood vessels aside from the heart, but the blood driven out from the anterior end of the heart is forced into the proboscis and runs back along the ventral side of the body, and from here it flows out into the legs. In general the direction of flow is centrifugal on the ventral side and centripetal on the dorsal side (except in the proboscis, where it is just the reverse). A thin membrane, which supports the

intestine, keeps the two streams apart (cf. Fig. 2, *sept.*). Dohrn's description of the heart agrees very closely with that of Hoek, it being an elongated sac with thin muscular walls, which, how-

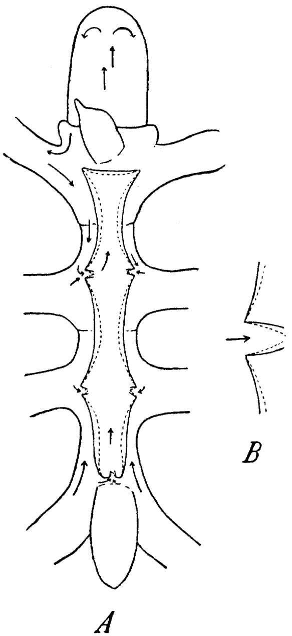

FIG. 1. *A*, apparent change in the shape of the heart with contraction and expansion, as seen when viewed from above in a living specimen of *Endeis spinosus*. Solid line, diastole; broken line, systole. The arrows show the course of the blood where its streaming could be observed; the opacity of the intestine and other organs prevented its being seen in other parts. *B*, a single lateral ostium with valve.

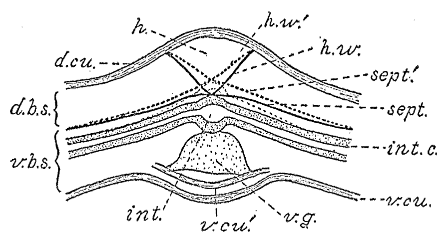

FIG. 2. Diagrammatic cross-section of the body of a pycnogonid through a pair of the lateral processes, illustrating the way in which the heart contracts: *d.b.s.*, dorsal blood space; *d.cu.*, dorsal cuticula; *h.*, lumen of heart; *h.w.*, side wall of heart (at diastole); *h.w.'*, position of side wall of heart at systole; *int.*, main longitudinal trunk of intestine; *int.c.*, intestinal cecum going to leg; *sept.*, transverse horizontal septum (at diastole); *sept.'*, position of transverse septum at systole; *v.b.s.*, ventral blood space; *v.cu.*, cuticula of ventral side, *v,cu.'*, posterior edge of underlapping cuticula of the preceding segment; *v.g.*, ventral ganglion. (Based on the cross-section of a species of *Nymphon* figured by Dohrn, 1881, pl. 15, fig. 10. The ovary, which lies between the intestinal ceca and the transverse septum, has been omitted for the sake of clearness.)

ever, do not completely enclose it, the dorsal wall being formed by the chitinous integument of the back (cf. Fig. 2).

In *Phoxichilidium femoratum* Loman (1907) found that a systole of the heart occurred two or three times each second, which would be 120 to 180 contractions to the minute. A count

of the rate of the heart beat of *Endeis spinosus* which I made at Woods Hole, September 4, 1904, showed 172 contractions per minute, the rate slowing down in a short time after the animal had been mounted under a cover glass. The next morning other specimens showed a rate of 126 to 136 beats per minute. Fig. 1, from a rough sketch made at the time, shows the position and shape of the heart; the dotted lines indicate the apparent change in shape as the muscular side walls contract, and the arrows show the direction of observable streaming of the corpuscles in the body fluid or blood. It must be remembered that owing to the attachment of the side walls to the dorsal integument they must be stationary at this point, the contraction of the muscles in the side walls tending to draw the sides together further down, thus reducing the capacity of the enclosed space (see Fig. 2). It is probable that with the alternate contraction and relaxation of the heart the transverse septum (*sept.*), which divides the body space into dorsal and ventral chambers, is raised (Fig. 2, *sept.*) and lowered to some extent, which would help to force the blood out into the legs at each systole and to draw blood from the legs into the pericardial space at the diastole.

The two pairs of lateral ostia, opposite the lateral processes of the body for the attachment of the second and third pairs of legs respectively, could be plainly distinguished; the single opening at the posterior end was somewhat less distinct. The streaming of the blood cephalad through this portion of the heart left no doubt, however, of the existence of such an opening, except in one case in which the blood could be seen to move back and forth in this region without a definite streaming forward. This would seem to confirm Dohrn's observation that in some cases there is no posterior terminal ostium, or at least it appears that if it existed in this instance it was closed and not functioning.

Although, on the whole, there appeared to be a real circulation from the body out into the legs and back, this was rendered more or less indefinite by the peristaltic contractions of the intestine, which imparted a sort of churning motion to the blood and kept it moving back and forth. This was especially evident in the more expanded femoral joints; in the basal parts of the leg and in the tibia a more definite streaming could be observed. The

contractions of the intestinal ceca in the legs are more or less irregular. There were usually a few (two to four) peristaltic waves in one direction, and then they would change and go the opposite way for an equal time. In some cases the contraction appeared to start at one point and pass from there in both directions along the intestine. In a specimen which had been mounted for some time under a cover glass these peristalses recurred at intervals of two or three seconds.

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